Intercomparison of Simulation Codes for Geologic Sequestration of CO_2

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RESEARCH OBJECTIVES

Mathematical models and numerical simulation tools play an important role in evaluating the feasibility of CO_2 storage in subsurface reservoirs, such as brine aquifers, producing or depleted oil and gas reservoirs, and coalbeds. We have designed and performed a code intercomparison study to explore the capabilities of numerical simulators to accurately and reliably model the important physical and chemical processes that would be taking place in CO_2 disposal systems. The overall objective of the study is to document and advance the state of the art in modeling CO_2 injection into subsurface reservoirs, and to establish credibility for currently available modeling approaches.

APPROACH

Berkeley Lab designed and directed the code intercomparison study. A set of eight test problems was assembled to examine flow processes during CO_2 injection into brine formations, depleted gas reservoirs, and oil reservoirs. Key issues addressed in these problems include (1) the thermodynamics of sub- and supercritical CO_2, and PVT properties of mixtures of CO_2 with other fluids, including (saline) water, oil, and natural gas; (2) the fluid mechanics of single and multiphase flow when CO_2 is injected into aquifers, oil reservoirs, and natural gas reservoirs; (3) coupled hydrochemical effects caused by interactions among CO_2, reservoir fluids, and primary mineral assemblages; (4) coupled hydromechanical effects, such as porosity and permeability change, caused by increased fluid pressures from CO_2 injection; and (5) space and time discretization effects. The test problems were distributed to interested groups of scientists and engineers, and the Internet was used as a convenient vehicle to help organize this effort.

ACCOMPLISHMENTS

Ten groups from six countries participated in the study, including Berkeley Lab, Stanford University, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Pacific Northwest National Laboratory, Alberta Research Council (Canada), Industrial Research Ltd. (New Zealand), CSIRO Petroleum (Australia), University of Stuttgart (Germany), and the Institut Français de Pétrol (France).

In the course of the study, a number of bugs were found and corrected in several simulation codes. Substantial agreement was achieved between results predicted from different simulators, but there exist areas with only fair agreement, as well as some significant discrepancies. Most discrepancies could be traced to differences in fluid property descriptions, an area that will clearly require continuing efforts by code developers to assure that realistic results can be obtained. Some disagreements were caused by effects from space and time discretization, while occasionally discrepancies were noted for which no rational explanation could be found.

A full presentation and discussion of results submitted by all groups are given in a laboratory report (Pruess et al., 2002). A separate report with a more detailed presentation of Berkeley Lab results for the saline-brine-formation problems is also available (Pruess and García, 2002). These reports, as well as other related materials, are available on the Web at http://www-esd.lbl.gov/GEOSEQ/.

SIGNIFICANCE OF FINDINGS

Although code development work undoubtedly must continue, this work has shown that codes are available now that can robustly model the complex phenomena accompanying geologic storage of CO_2, and with quantitatively similar results.

RELATED PUBLICATIONS

Pruess, K., and J. García. Solutions of test problems for disposal of CO_2 in saline aquifers. Berkeley Lab Report LBNL-51812, 2002.

Pruess, K., J. García, T. Kovscek, C. Oldenburg, J. Rutqvist, C. Steefel, and T. Xu, Intercomparison of numerical simulation codes for geologic disposal of CO_2. Berkeley Lab Report LBNL-51813, 2002.

Pruess, K., C.F. Tsang, D. H.-S. Law, and C.M. Oldenburg. Intercomparison of simulation models for CO_2 disposal in underground storage reservoirs. Berkeley Lab Report LBNL-47353, 2000.

ACKNOWLEDGMENTS

This work was supported by the National Energy Technology Laboratory (NETL) of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.